RECLAMATION

*Managing Water in the West*

Final Environmental Assessment

# Sacramento Deep Water Ship Channel Nutrient Enrichment Project

**U.S. Department of the Interior**
**Bureau of Reclamation**
**Mid Pacific Region**

**September 2018**

# Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

**U.S. Department of the Interior**
**Bureau of Reclamation**
**Mid Pacific Region**

**September 2018**

# Table of Contents



# List of Tables



# List of Appendices

# List of Acronyms and Abbreviations

| | |
|---|---|
| µg/L | microgram/Liter |
| µS/cm | microsiemens/cm |
| BMP | Best Management Practices |

| | |
|---|---|
| CEQ | Council on Environmental Quality |
| CFR | Code of Federal Regulations |
| CNDDB | California Natural Diversity Database |
| CNPS | California Native Plant Society |
| CRF | California Red-legged Frog |
| CV | Central Valley |
| CVP | Central Valley Project |
| CWA | Clean Water Act |
| DIN | Dissolved Inorganic Nitrate |
| DOC | Dissolved Organic Carbon |
| DPS | Distinct Population Segments |
| EA | Environmental Assessment |
| EFH | Essential Fish Habitat |
| ESA | Endangered Species Act |
| GGS | Giant Garter Snake |
| IEP | Interagency Ecological Program |
| IPaC | Service Information for Planning and Conservation website |
| ITA | Indian Trust Assets |
| LAA | May Affect, and Likely to Adversely Affect |
| MBTA | Migratory Bird Treaty Act |
| MGD | million gallons per day |
| M&I | Municipal and Industrial |
| NE | No Effect |
| NEPA | National Environmental Policy Act |
| $NH_4$-N | Ammonium-as nitrogen |
| NHPA | National Historic Preservation Act |
| NLAA | Not Likely to Adversely Affect |
| NL72 | Navigation Light 72 |
| NL74 | Navigation Light 74 |
| NMFS | National Marine Fisheries Service |
| $NO_3$-N | Nitrate- as nitrogen |
| NPDES | National Pollutant Discharge Elimination System |
| NPPA | Native Plant Protection Act |
| $PO_4$-P | Orthophosphate-as phosphorus |
| Quad | Quadrangle |
| Reclamation | Bureau of Reclamation |
| Service | U.S. Fish and Wildlife Service |
| Si | Silica |
| SHPO | State Historic Preservation Officer |
| SSC | Sacramento Deep Water Ship Channel |
| SWRCB | State Water Resources Control Board |
| TSS | Total Suspended Solids |
| TDN | Total dissolved nitrogen |
| TDP | Total dissolved phosphorus |
| TN | Total nitrogen |
| TP | Total phosphorus |

| | |
|---|---|
| USGS | US Geological Survey |
| VOC | Volatile Organic Compound |
| VSS | Volatile Suspended Solids |
| WSP | West Sacramento Port |

# Section 1 Introduction

In conformance with the National Environmental Policy Act, 42 U.S.C. § 4431 et seq. (NEPA), as amended, the Bureau of Reclamation (Reclamation) has prepared this Environmental Assessment (EA) to evaluate and disclose potential environmental impacts associated with implementation of the Sacramento Deep Water Ship Channel Nutrient Enrichment Project (Proposed Action).

This EA describes the existing environmental resources in the project area, evaluates the impacts of the No Action and Proposed Action alternatives on the resources, and proposes measures to avoid, minimize, or mitigate any adverse impacts. This EA was prepared in accordance with NEPA, Council on Environmental Quality (CEQ) regulations (40 Code of Federal Regulations (CFR) 1500-1508), and Department of the Interior Regulations (43 CFR Part 46).

## 1.1 Background

Reclamation operates the Central Valley Project (CVP), a system of reservoirs, power plants, operable gates, pumping plants and canals that supply water for irrigation, municipal and industrial use and for wildlife refuges in the Central Valley. CVP operations are thought to contribute to the decline of delta smelt (*Hypomesus transpacificus*), an endemic fish listed as 'threatened' under the federal Endangered Species Act (ESA), by adversely affecting the extent and quality of its critical habitat. Under the Central Valley Project Improvement Act of 1992, Reclamation has the authority to fund activities that have the potential to reduce CVP impacts on smelt and their critical habitat and to undertake actions to improve Delta habitat conditions.

Conceptual models for the pelagic organism decline in the Sacramento-San Joaquin Delta suggest the potential for both "top-down" and "bottom-up" drivers of fish abundance. As in many estuaries, fish and other higher trophic level production in the open waters of the Delta region is fueled by phytoplankton production. However, the Delta has notably low phytoplankton production and biomass (Van Nieuwenhuyse 2007; Jassby 2008) resulting in low overall aquatic ecosystem productivity compared to other systems. Consequently, open waters of the Delta are considered food-limited (Kimmerer 2002). Increasing food resources (i.e., phytoplankton and zooplankton) would thus be expected to have a beneficial effect on the entire system, as well as for endangered native species such as Delta smelt.

Previous research on the Toe Drain in the Yolo Bypass (Frantzich and Sommer 2015) demonstrated that pulses of algae-rich waters associated with enhanced net flows through the Toe Drain (as measured at the Lisbon Weir) can "seed" a significant algal bloom throughout the north Delta (Figure 1). A plausible mechanism for this phytoplankton bloom initiation is that the input of a large algal seed source from the Toe Drain into the relatively nutrient-rich waters from

the lower Sacramento River (primary nutrient source is Sacramento Regional wastewater treatment facility) results in greatly enhanced phytoplankton production rates that exceed zooplankton and clam (*Corbicula*) grazing pressures. This allows the phytoplankton bloom to persist and propagate downstream until it is exported to the Bay.

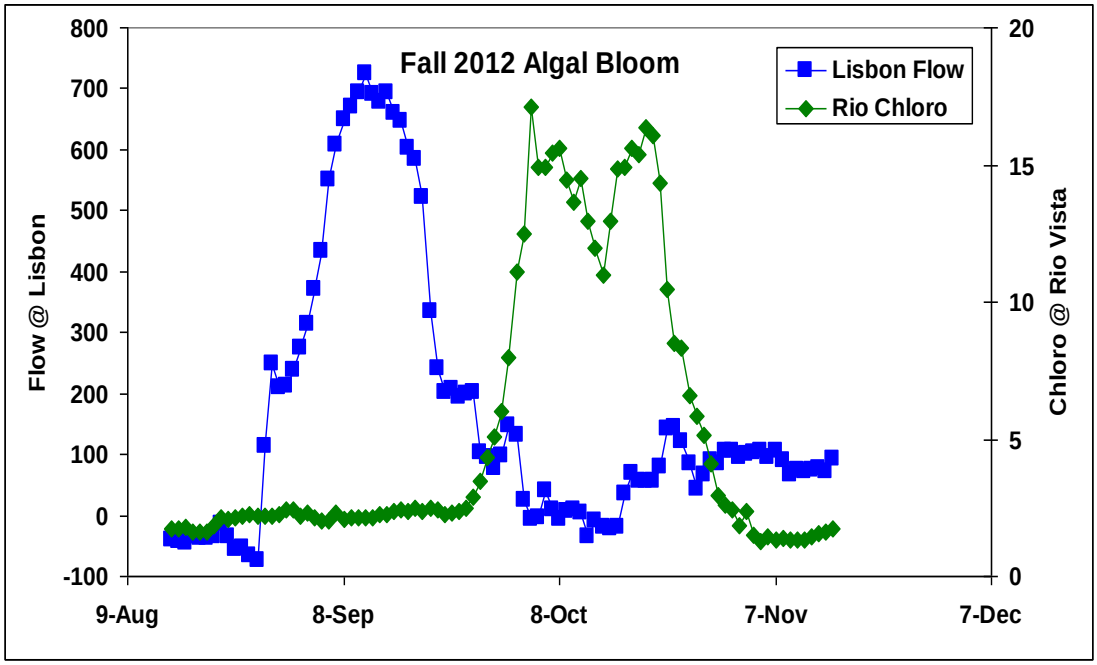


**Figure 1. Outflow from Yolo toe drain and chlorophyll concentration (metric of phytoplankton standing stock) in the main stem Sacramento River at Rio Vista during fall of 2012.**

A goal for food resource management in the north Delta would be to increase the standing stock of algal biomass (chlorophyll concentration) from the current range of 1-3 µg/L (microgram/Liter) to roughly 10 µg/L. A chlorophyll level of roughly10 µg/L could support relatively high zooplankton production (Mueller-Solger et al. 2002) without adversely affecting water quality (e.g., dissolved oxygen concentration).

To optimize the export of food resources from the Sacramento Deep Water Ship Channel (SSC), Reclamation's multi-year (2012 – present) dataset suggests that nitrogen additions should enhance both primary (phytoplankton) and secondary (zooplankton) production and standing crops. It is hypothesized that it should be possible to manipulate the SSC in a manner that would allow Reclamation to grow up standing stocks of phytoplankton and zooplankton and pulse these food resources into the north Delta where the phytoplankton/zooplankton bloom may be self-sustaining for a period of time (roughly1 month, but depending on river flows). In the SSC, there is the potential to control both water flow rates (diversions from Sacramento River) and nutrient concentrations (e.g., through nutrient additions) should preliminary studies support the efficacy of the system to enhance food resources in the north Delta.

The SSC consists of three longitudinally distinct zones as illustrated by the specific conductance (EC). These zones include an area of trapped water in the upper section (lentic conditions), a zone of mixing in the mid-reach, and the lower zone that experiences tidal exchange twice a day (Figure 2). Seasonally, small blooms of phytoplankton and zooplankton are observed in the "old water" zone (Figure 3 and 4); however, these food resources are trapped in this zone with minimal advection to the tidal mixing zone where it could enter into the north Delta. The more persistent blooms observed below the gates in the West Sacramento Port (WSP) are believed to be due to nutrient inputs from leakage through the gate (especially during high flow periods) and groundwater inputs from the Sacramento River. These observations suggest that nutrient enrichment has the potential to stimulate algal and zooplankton production in the SSC.

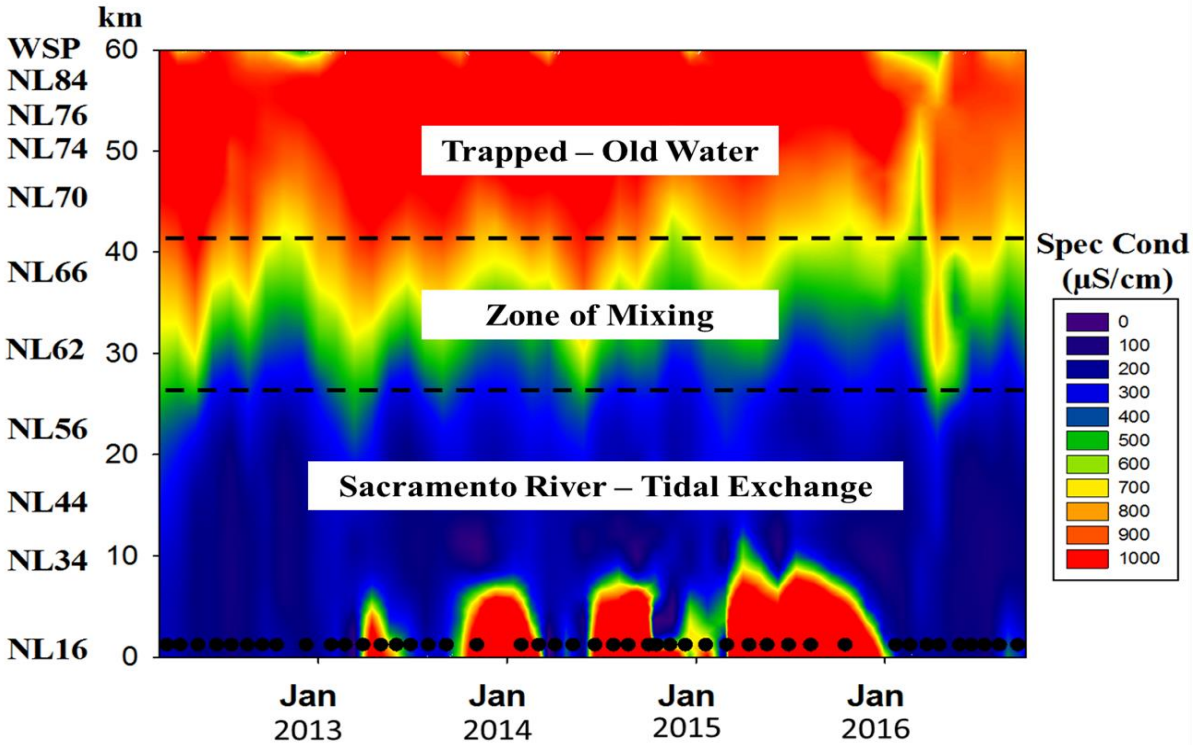


**Figure 2. Longitudinal variation of specific conductance (saltiness) in the Sacramento ship channel, 2012-2016.**

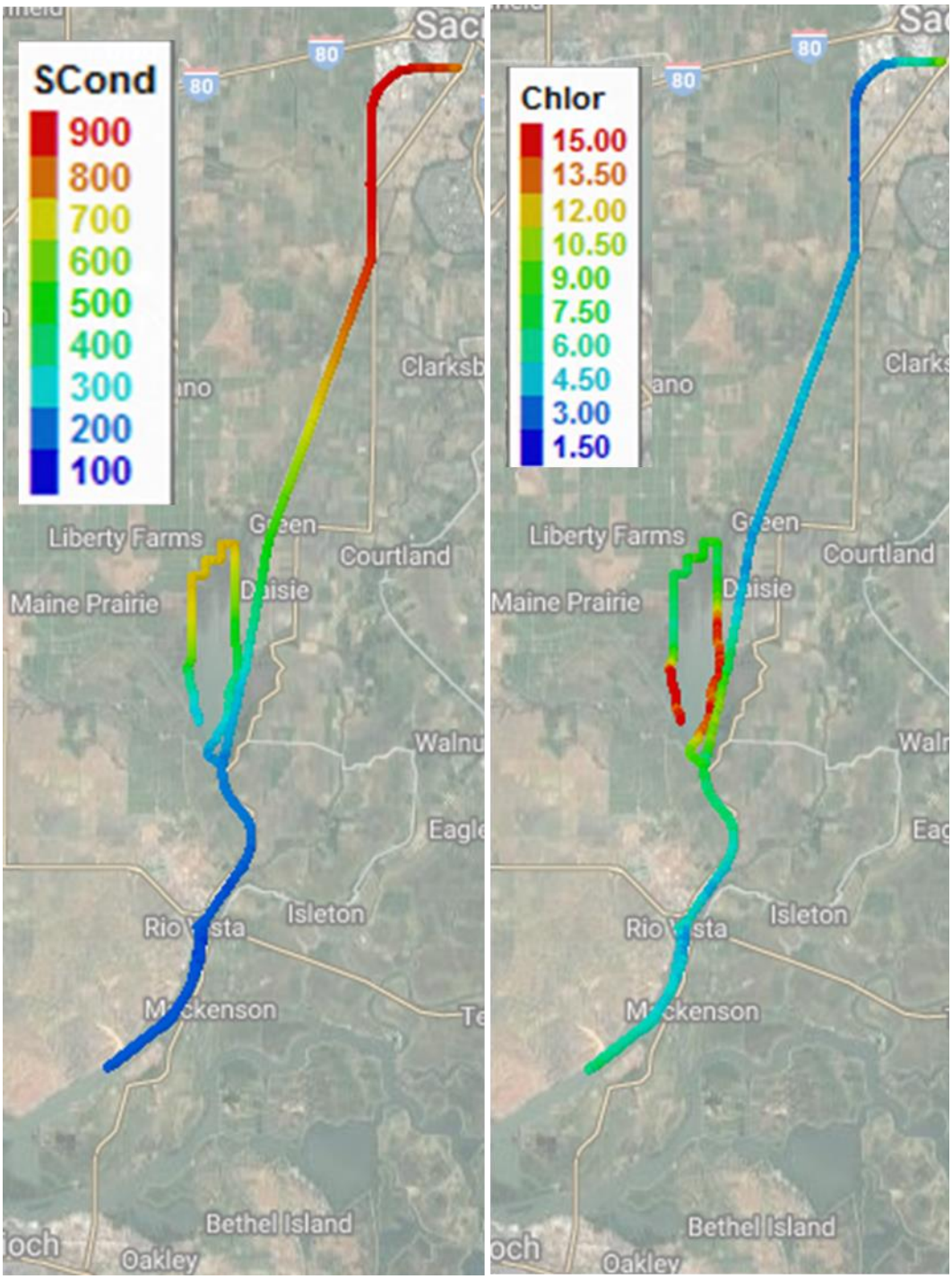


**Figure 3. Longitudinal variation in specific conductance and chlorophyll concentration in the main stem Sacramento River, Cache Slough Complex and Sacramento ship channel, July 26, 2012.**

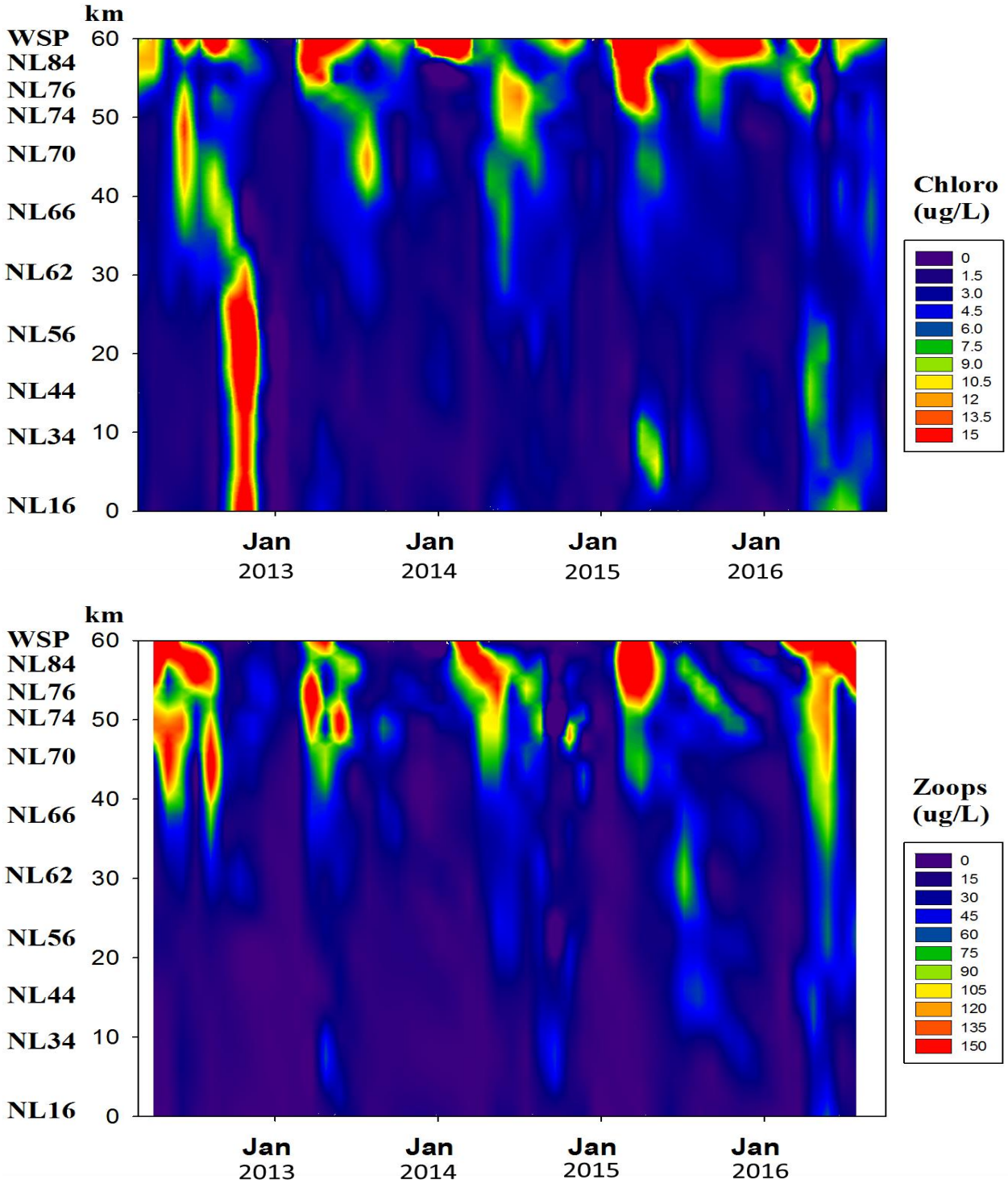


**Figure 4. Longitudinal variation in chlorophyll concentration (top) and zooplankton biomass (bottom) in the main stem Sacramento River and ship channel, 2012-2016.**

Given the consumption of nutrients by algal growth, dissolved inorganic nitrogen (DIN) ($NH_4$ + $NO_3$) is depleted to low levels (<0.1 mg N/L) in the upper SSC during the summer months (Figure 5). Thus, primary production is limited by the

lack of bioavailable N for much of the spring-summer-fall period. Nitrogen is depleted faster than phosphorus (the other major potentially limiting nutrient) in part because denitrification (microbial conversion of nitrate to nitrogen gas) results in the permanent loss of nitrogen from the water column over time. By contrast, no such loss process exists for phosphorus. Thus, the DIN:$PO_4$-P molar ratio is generally less than 6 throughout the year compared to a Redfield N:P ratio of roughly16 for algae (Figure 6). These conditions suggest that nitrogen enrichment, especially during the summer growing season, could stimulate primary production that in turn should theoretically lead to higher production of zooplankton.

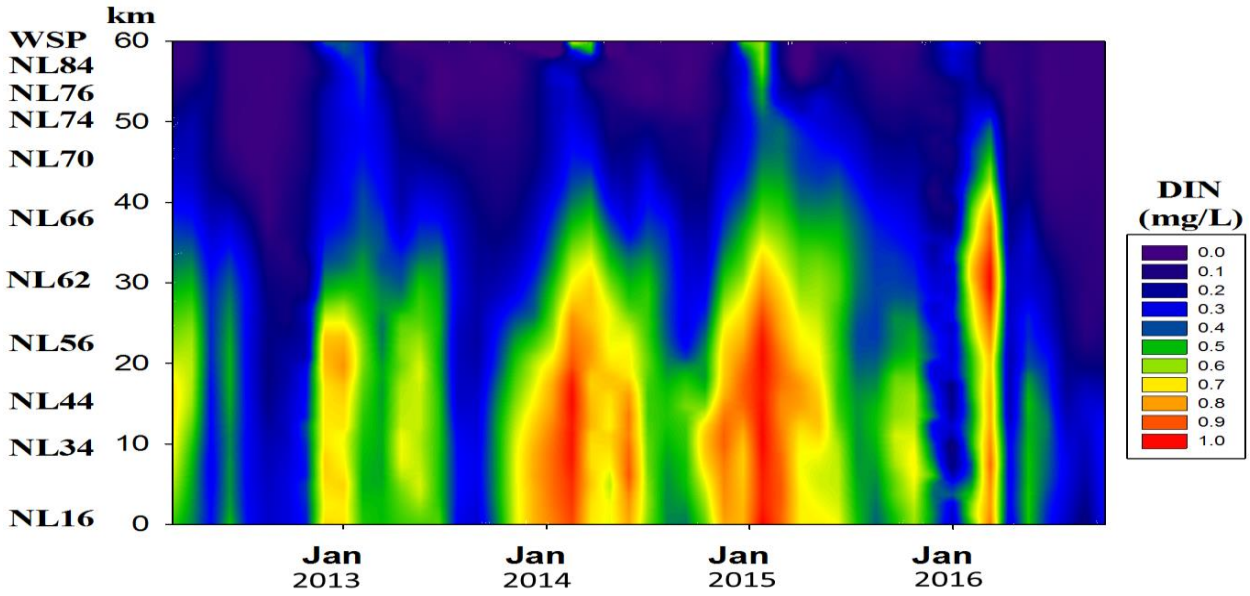


**Figure 5. Longitudinal variation in dissolved inorganic nitrogen (ammonium plus nitrate-nitrite) concentration in the main stem Sacramento River and ship channel, 2012-2016.**

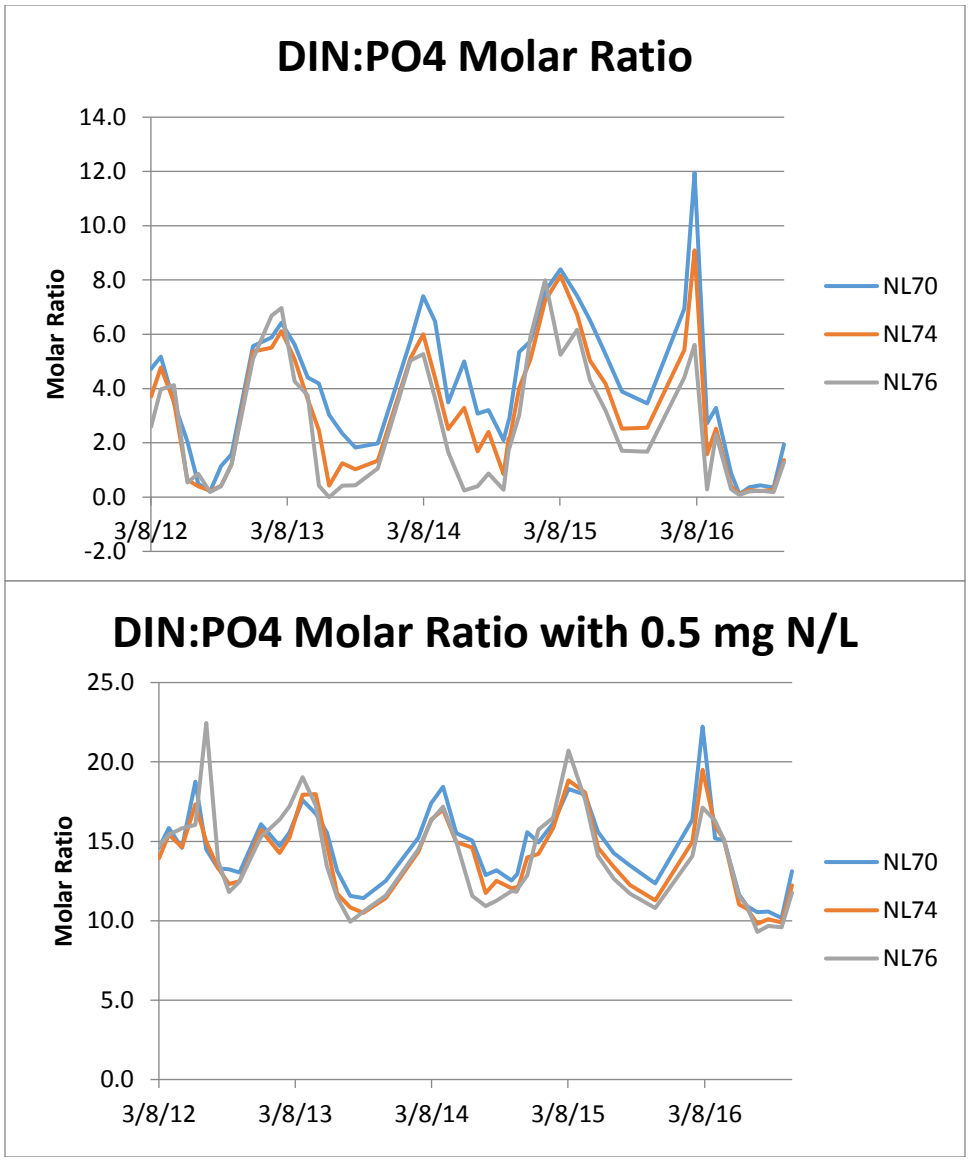


**Figure 6. Variation in ratio of dissolved inorganic nitrogen to orthophosphate concentration at three stations in the upper Sacramento ship channel, 2012-2016 (top) and projected ratio after addition of fertilizer (bottom).**

## 1.2 Purpose and Need for the Project

The purpose of the Proposed Action is to determine if the addition of nitrogen can stimulate plankton (fish food organisms) production in a section of the SCC that currently does not exchange water with the rest of the Delta. This pilot project is an initial step in a broader effort to determine the potential ecological benefits of repairing or replacing the West Sacramento lock system (locks) which could then be operated to hydraulically reconnect the ship channel with the main stem Sacramento River. A functioning sector gate could be used to adaptively manage net flow of Sacramento River water down the ship channel as a way to export ship channel plankton to stimulate plankton production in the north Delta.

The need for the action derives from the low production levels of phytoplankton biomass in the Bay-Delta ecosystem, contributing to a food-limited habitat for delta smelt.

# Section 2 Alternatives Including the Proposed Action

This EA considers two possible alternatives: the No Action Alternative and the Proposed Action. The No Action Alternative reflects future conditions without the Proposed Action and serves as a basis of comparison for determining potential impacts to the human environment that would result from implementation of the Proposed Action.

Identification of the reasonable range of alternatives for this EA was based upon consideration of the purpose and need. Additional alternatives were considered but eliminated due to them being substantially similar in design and impacts as the Proposed Action (40 C.F.R. § 1502.14(a)).

## 2.1 No Action Alternative

Under the No Action Alternative, Reclamation would not apply nitrogen into the SSC, nor would the broader effort of adaptively managing and exporting plankton to the north Delta occur. Regions of the Bay-Delta ecosystem and habitat for delta smelt would continue to be food-limited.

## 2.2 Proposed Action Alternative

Reclamation proposes a nitrogen enrichment pilot study at Navigation Light 74 (NL74) to test nutrient stimulation of primary and secondary production. NL74 is located within the "old" water zone and, therefore, experiences no net advection to the north Delta. Seasonally (summer), the DIN concentrations in the water column at NL74 are depleted to <0.1 mg N/L while $PO_4$-P concentrations (data not shown) remain in a narrow range of 0.10 – 0.12 mg P/L (Figure 7). Chlorophyll-a concentrations vary seasonally between 3 to 10 µg/L (Figure 8).

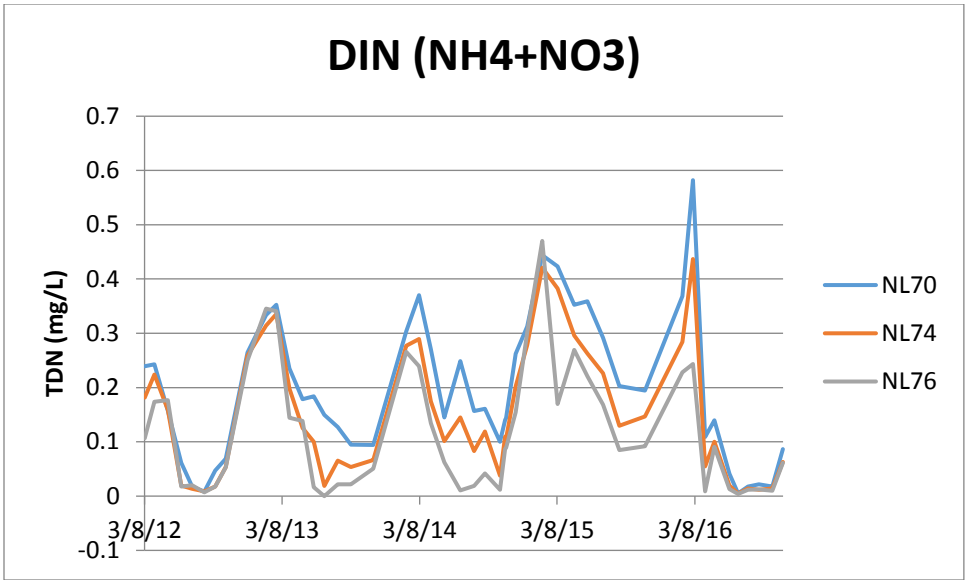


**Figure 7. Variation in dissolved inorganic nitrogen at three locations in the upper Sacramento ship channel, 2012-2016.**

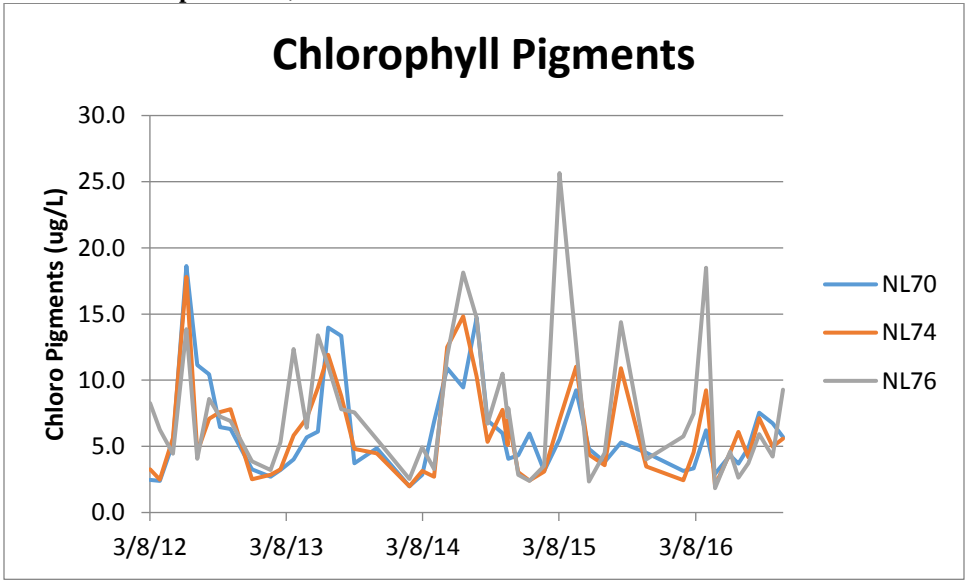


**Figure 8. Variation in chlorophyll concentration (phytoplankton standing stock) at three locations in the upper Sacramento ship channel, 2012-2016.**

An important consideration is whether nitrogen enrichment will decrease the algal doubling-time (increase reproduction rate) as postulated by Michaelis-Menten kinetics (Figure 9). At a typical summer-time DIN concentration of 0.05 mg/L, the doubling rate for the illustrated diatom is roughly 0.3 $d^{-1}$. If DIN concentrations were increased to 0.5 mg/L, the doubling rate is expected to increase to roughly 0.7 $d^{-1}$. Thus, primary production could be stimulated by a factor of 2×, potentially increasing zooplankton productivity and allowing the algae to outpace the grazing pressure exerted by the clam *Corbicula*.

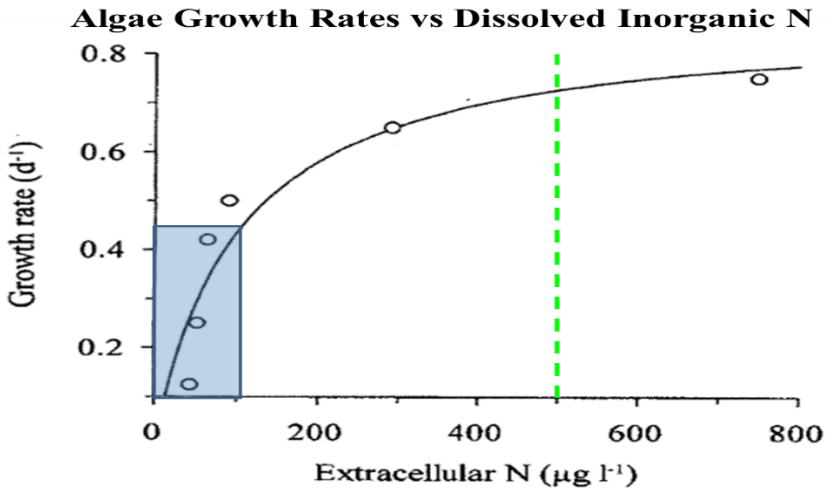


**Figure 9. Relationship between dissolved inorganic nitrogen concentration and doubling rate of phytoplankton (*Cyclotella*) under laboratory conditions.**

The experiment will add sufficient nitrogen to achieve a target DIN of 0.5 mg N/L. This DIN level is expected to increase the doubling rate of algae by a factor of roughly 2×, a level that should be easily detectable by field measurements. Moreover, the addition of 0.5 mg N/L will increase the DIN:$PO_4$-P molar ratio to a value of roughly 15, which is close to the Redfield ratio for algae. Finally, Reclamation's previous studies of nutrient:chlorophyll stoichiometry in the north Delta indicate that 0.5 mg N/L could, under ideal conditions, produce a maximum of 50 µg/L of chlorophyll. The actual chlorophyll concentration is likely to be substantially lower, however, owing to phytoplankton loss processes such as grazing and sedimentation and the conversion of nitrate to nitrogen gas by denitrifying bacteria. The N enrichment target of 0.5 mg/L compares to maximum seasonal DIN levels of roughly 0.4 mg/L experienced naturally at or around NL74 (Figure 7). The enrichment study was originally scheduled to occur in June to coincide with the maximum solar radiation inputs and the lowest DIN concentrations of the year, but at the request of the City of West Sacramento has been rescheduled for late September. Data collected in the ship channel since 2016 indicate that low DIN persists until late September, so this delay will not compromise study objectives.

The addition of nitrogen will be in the form of nitrate, which is the dominant form of N contributing to DIN in the upper SSC. The nitrogen, in the form of calcium nitrate commercial fertilizer, will be added to a 400 m reach of the SSC centered near NL74. The precise location will depend on the tides. Assuming a background DIN concentration of 0.1 mg/L and a target DIN value of 0.5 mg N/L, a total of 112 kg N (equivalent to 723 kg or 1593 lbs of $Ca(NO_3)_2$) would be applied. Aerial application (via crop duster) of the solid fertilizer source will be conducted in order to achieve a relatively uniform distribution pattern of fertilizer to the water surface. Crop duster application via GPS guided control provides a much better option for uniform distribution than application from a boat. The crop

duster will provide certification that the equipment used will be pesticide/herbicide-free.

### 2.2.1 Monitoring Plan

Since each water parcel within the SSC has a distinct longitudinal specific conductance (Figure 2), we can easily identify any given water parcel by its specific conductance. We will place YSI water quality sondes (chlorophyll fluorescence, dissolved oxygen, temperature, specific conductance, turbidity) at depths of 1 and 5 meters within the water column at NL72 (downstream of the fertilizer application site but still within the fertilized plug's tidal excursion)(Figure 10). These sondes will be able to monitor the entire plug of fertilizer enrichment during a tidal cycle by using the specific conductance to identify each water parcel as if moves up- and down-stream during a tidal cycle.

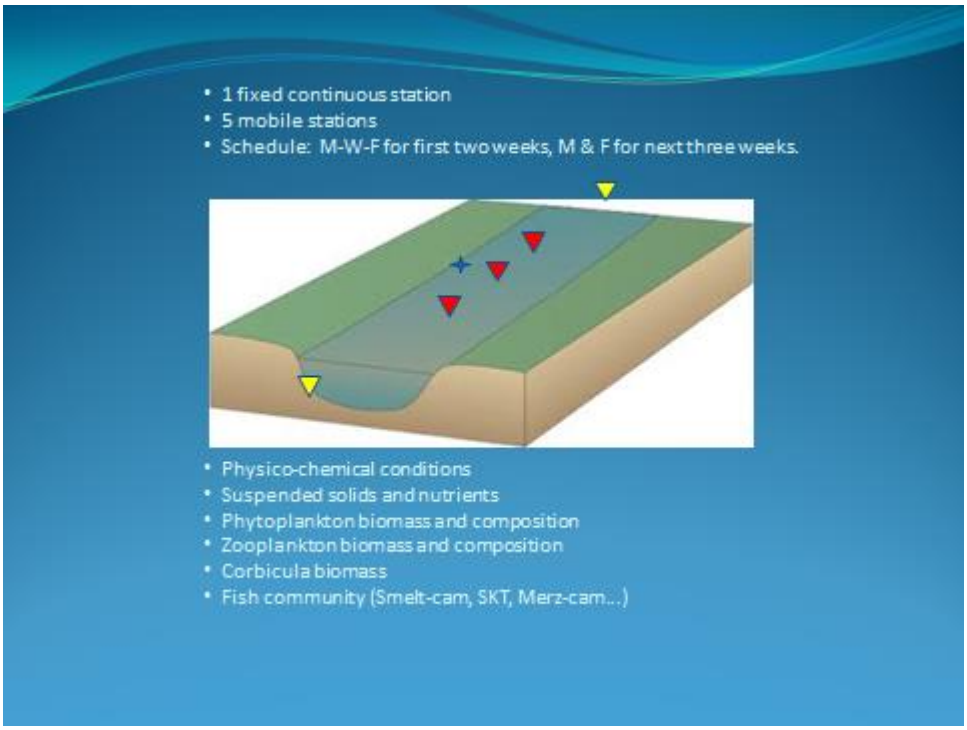


**Figure 10. Schematic of monitoring locations within and up and downstream of experimental reach centered on Navigation Light 74 in the upper Sacramento Deepwater ship channel.**

Prior to and following nutrient addition, YSI depth profiles will be collected at a 2 day interval during the first 10 days and at 5 day intervals to a total of roughly 30 days post-nutrient enrichment. These longitudinally-based vertical profiles will be used to calculate whole system metabolism using the differences in dissolved oxygen concentrations from morning to evening. Sediment oxygen demand will be determine for use in the metabolism calculations and reaeration rates will be calculated using water column dissolved oxygen concentrations and metrological

data.

Grab samples from 1, 3 and 8 meters will be collected at the center point and +/- 50 meters upstream and downstream of the central nutrient plug. Grab samples will also be collected 200 meters upstream and downstream of the nutrient addition boundary for use as a reference condition and to determine if any nutrient dispersion has occurred. Grab samples will be analyzed for nutrients (TN, TDN, $NH_4$, $NO_3$, TP, TDP, $PO_4$, Si), extractable chlorophyll/pheophytin pigments, dissolved organic carbon (DOC), turbidity, and total and volatile suspended solids concentration (TSS/VSS). A subsample from the 1 m depth will be used for quantification of each phytoplankton species' biovolume. In addition, 5 L of raw water filtered through a 150-micron mesh will be collected and transported back to the University of California, Davis lab to determine phytoplankton doubling rate. A vertical zooplankton tow will be performed using a 150 µm tow net. The dry weight equivalent of each zooplankton species will be determined. Phytoplankton and zooplankton samples will be preserved in Lugol's solution and identified using standard methods.

# Section 3 Affected Environment and Environmental Consequences

This section describes the affected environment and evaluates the environmental consequences that may occur with implementation of the Proposed Action and the No Action Alternative. Potential impacts on several environmental resources were examined and found to be minimal or nonexistent. These resources include:

Indian Trust Assets (ITAs): ITAs are legal interests in assets that are held in trust by the U.S. for federally recognized Indian tribes or individuals. There are no Indian reservations, Rancherias or allotments in the project area. The nearest ITA is the Wilton Rancheria, about 18 miles away.

Indian Sacred Sites: Sacred sites are defined in Executive Order 13007 (May 24, 1996) as "any specific, discrete, narrowly delineated location on Federal land that is identified by an Indian tribe, or Indian individual determined to be an appropriately authoritative representative of an Indian religion, as sacred by virtue of its established religious significance to, or ceremonial use by, and Indian religion; provided that the tribe or appropriately authoritative representative of an Indian religion has informed the agency of the existence of such a site." There are no identified Indian Sacred Sites within the Proposed Action area; therefore this project would not inhibit use or access to any Indian Sacred Sites.

Cultural Resources: Reclamation has determined that the Proposed Action is type of undertaking that does not have the potential to cause effects on historic properties, should such properties be present, pursuant to 36 CFR § 800.3(a)(1). As such, Reclamation has no further obligations under 54 U.S.C. § 306108, commonly known as Section 106 of the National Historic Preservation Act (NHPA).

Environmental Justice: Executive Order 12898 requires each Federal agency to identify and address disproportionately high and adverse human health or environmental impacts, including social and economic effects of its program, policies, and activities on minority populations and low-income populations. The Proposed Action would not result in adverse human health or environmental impacts to minority or low-income populations.

## 3.1 Biological Resources

### 3.1.1 Affected Environment

The project area is centered at NL74 (38.5062 N, 121.5836 W) in the upper SSC, located West of Sacramento City. The SSC includes both natural habitat and

man-made navigation features, beginning with the Sacramento River near Suisun Bay. The SSC accounts for approximately 13% of the Sacramento River's overall area where the two overlap. The SSC diverges from the Sacramento River into the man-made channel approximately 2 miles north of Rio Vista. In total, the SSC comprises an approximately 17-mile section of the Sacramento River and a 29-mile navigation channel, of which 25 miles are man-made (USACE 2011).

Tidal wetlands, tidal mudflats, and riparian habitat are present along portions of levees and the banks of SSC. Land adjacent to the banks of the SSC as it passes through the Delta is used primarily for agricultural purposes with pockets of residential, commercial, and industrial development. Within the man-made portion of the SSC, warm water temperatures (in summer, generally 10 degrees Fahrenheit [°F] warmer than in the Sacramento River portion), higher salinities, lack of riparian vegetation, and the presence of predators combine to create conditions that generally are unfavorable to rearing and out-migrating juvenile salmonids (NMFS 2006).

Typical wildlife species associated with the riparian and floodplain communities include mammals such as striped skunk, raccoon, and gray fox. Riparian bird species include red-shouldered hawk, wood duck, great blue heron, black crowned night heron. Amphibians and reptiles include Pacific tree frog, Pacific gopher snake, garter snake, and western pond turtle. Special status species that associate with riparian and floodplain habitats include federally listed western yellow-billed cuckoo and valley elderberry longhorn beetle (Reclamation, 2016).

## Special Status Species

Special-status species addressed in this section include plants and animals that are legally protected or are otherwise considered sensitive by Federal, State, or local resource conservation agencies and organizations. These include species that are State listed and/or Federally listed as rare, threatened, or endangered; those considered as candidates or proposed for listing as threatened or endangered; and plants considered by the California Native Plant Society (CNPS) to be rare, threatened, or endangered.

### California Native Plant Protection Act

The Native Plant Protection Act (NPPA) of 1977 protects rare and endangered plants in California and prohibits take of endangered or rare native plants. Based on a review of California Natural Diversity Database (CNDDB) and CNPS database searches for rare and endangered plant species was conducted for the surrounding U.S. Geological Survey (USGS) Quads (quadrangle) (2015), the federally threatened Colusa Grass and federally endangered Solano Grass returned occurrences. Under the California Rare Plant Rank they are listed as 1B (Plants Rare, Threatened, or Endangered in California or Elsewhere). CNPS further designates the level of endangerment with a Threat Rank, with .1 meaning a plant is seriously threatened, a rank of .2 means fairly threatened, and a rank of .3 means not very threatened in California. The following is a list of rare and endangered plants with recorded occurrences surrounding Quads:

- Solano Grass (*Tructoria mucronata*) 1B.1 Federally Endangered
- Colusa Grass (*Neostapfia colusana*) 1B.1 Federally Threatened

Due to the scale of the Proposed Action, any impacts to existing vegetation will be negligible and unlikely to occur within the project area.

**Migratory Bird Treaty Act**
A list of bird species with recorded occurrences within the surrounding quads was also obtained from the CNDDB (2015). The list was compared to the Service's list of protected species under the Migratory Bird Treaty Act (MBTA) of 1918 (2015a). There are no protected migratory bird species with recorded occurrences in the Proposed Action project area and are, therefore, not discussed further.

**Threatened or Endangered Species**
The U.S. Fish and Wildlife Service (Service) and National Marine Fisheries Service (NMFS) have jurisdiction over federally listed threatened and endangered species. An endangered species is defined as "…any species which is in danger of extinction throughout all or a significant portion of its range." A threatened species is defined as "…any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (16 USC Section 1532). Section 9 of the Endangered Species Act of 1973 (ESA) makes it illegal to "take" (defined as to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in such conduct") endangered and threatened species (16 USC 1538).

A special-status species list was generated from the Service Information for Planning and Conservation (IPaC) website for the surrounding area on March 29, 2018 (USFWS 2017). The following Table 3 includes those federally listed species with recorded occurrences within the surrounding USGS 7.5-minute Quads based on the CNDDB (2015). The table also includes the species' status, determination of impacts from the Proposed Action, and a summary of the rationale supporting the determination.

| Table 1 – Special Status Species List | | | | |
|---|---|---|---|---|
| **Common Name** | **Scientific Name** | **Status[1]** | **Effect[2]** | **Summary of Effects Determination[3]** |
| **Plants** | | | | |
| Colusa Grass | *Neostapfia colusana* | FT | NE | Occurences[4] and Critical Habitat outside of the Action Area |
| Solano Grass | *Tuctoria mucronata* | FE | NE | Occurences[4] and Critical Habitat outside of the Action Area |
| **Invertebrates** | | | | |
| Delta Green Ground Beetle | *Elaphrus viridis* | FT | NE | Occurences[4] and Critical Habitat outside of the Action Area |
| San Bruno Elfin Butterfly | *Callophrys mossil bayensis* | FE | NE | |
| Valley Elderberry Longhorn Bettle | *Desmocerus californicus dimorphus* | FT | NE | Occurences[4] and Critical Habitat outside of the Action Area |
| Conservancy Fairy Shrimp | *Branchinecta conservation* | FE | NE | Occurences[4] and Critical Habitat outside of the Action Area |
| Vernal Pool Fairy Shrimp | *Branchinecta lynchi* | FT | NE | Occurences[4] and Critical Habitat outside of the Action Area |
| Vernal Pool Tadpole Shrimp | *Lepidurus packardi* | FE | NE | Occurences[4] and Critical Habitat outside of the Action Area |
| **Birds** | | | | |
| California Clapper Rail | *Rallus longirostris obsoletus* | FE | NE | |
| Lest Bell's Vireo | *Vireo bellii pusillus* | FE | NE | Occurences[4] and Critical Habitat outside of the Action Area |
| Yellow-billed Cuckoo | *Coccyzus americanus* | FT | NE | Occurences[4] and Critical Habitat outside of the Action Area |
| **Amphibians** | | | | |
| California Red-legged Frog | *Rana draytonii* | FT | NE | Occurences[4] and Critical Habitat outside of the Action Area |
| California Tiger Salamander | *Ambystoma californiense* | FT | NE | Occurences[4] and Critical Habitat outside of the Action Area |
| **Fish** | | | | |
| Delta Smelt | *Hypomesus transpacificus* | FT | NLAA | |
| **Reptiles** | | | | |
| Giant Garter Snake | *Thamnophis gigas* | FT | NE | The giant garter snake inhabits marshes, sloughs, ponds, small lakes, low-gradient streams, and other waterways and agricultural wetlands, such as irrigation and drainage canals and rice fields. Unlikely to occur due to a lack of suitable habitat. |

[1] Status: Federal Listing (**FE**: Endangered; **FT**: Threatened; **X**: Critical Habitat)
State Listing (**SE**: Endangered; **ST**: Threatened; **SC**: Candidate)
**MBTA**: Migratory Bird Treaty Act
[2] Effects determination
**NE**: No Effect to federally listed species anticipated from the Proposed Action.
**NLAA**: Not Likely to Adversely Affect with Environmental Protection Measures
**LAA**: May Affect, and Likely to Adversely Affect
[3] Summary of rationale supporting determination
[4] California Natural Diversity Database 2014 recorded occurrences in the surrounding 9 Quads.

### Vernal Pool Species

Vernal pools are ephemeral wetlands that fill during the rainy season and disappear during the dry season. During the time water is present they provide unique habitat for species like vernal pool fairy shrimp, vernal pool tadpole shrimp, and Colusa grass. Revised critical habitat for vernal pool crustaceans was designated on August 11, 2005 (70 FR 46923). There is no Critical Habitat for vernal pool species within the Proposed Action area.

### Giant Garter Snake (*Thamnophis gigas*)

Giant garter snakes (GGS) require habitat with adequate water during their active season and emergent herbaceous wetland vegetation (USFWS 2006a). GGS also require higher elevation upland habitat. Rice production areas, irrigated agriculture, and channels and canals provide the majority of GGS habitat in the Central Valley. GGS typically breed in March and April with young born late July through early September (Hansen and Hansen 1990).

### Delta Smelt (*Hypomesus transpacificus*)

Delta Smelt were listed as threatened under the ESA on March 5, 1993 (58 FR 12854). Critical habitat for Delta Smelt includes all water and submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained in the legal Delta (as defined in Section 12220 of the California Water Code) (USFWS 1994a). Through the Proposed Action, an increase in food resources (i.e. phytoplankton and zookplankton) would be expected to have a beneficial effect on the entire Delta system, as well as for endangered native species such as Delta Smelt. As mentioned previously, a target level of DIN of 0.5mg N/L would not be expected to have any detrimental aquatic ecosystem effects, such as eutrophication and hypoxia, and, therefore, would not have a detrimental effect on Delta Smelt because a DIN of 0.5 mg/L is the concentration that occurs naturally before

nitrogen is drawn down to below detection by phytoplankton uptake.

**California Central Valley Steelhead Distinct Population Segments (DPS) (*Oncorhynchus mykiss*)**

California Central Valley (CV) Steelhead were listed as threatened under the ESA on January 5, 2006 (71 FR 834) and include all naturally spawned populations of steelhead in the Sacramento and San Joaquin rivers and their tributaries, excluding steelhead from San Francisco and San Pablo bays and their tributaries and two artificial propagation programs: the Coleman National Fish Hatchery and Feather River Fish Hatchery steelhead hatchery programs. The DPS excludes steelhead spawned and reared at Nimbus Fish Hatchery. Critical habitat was designated for CV steelhead on September 2, 2005 and includes the Sacramento delta watershed (70 FR 52488). As described for Delta Smelt, CV Steelhead will not be impacted by the Proposed Action. This is in part due to the proposed target level of DIN of 0.5mg N/L, which is not expected to have any detrimental aquatic ecosystem effects and will likely have a beneficial effect of increasing food resources for native fish. In addition, because there is no hydrological connection between SSC and the Sacramento River, steelhead do not use the man-made portion of the SSC for migration or spawning. While it is possible that steelhead use the upper portion of the water column within the man-made portion of the SSC as habitat for rearing, it is unlikely due to the absence of CV steelheads during fish community surveys in SSC conducted in 2008 (SWCA 2009).

**Critical Habitat**

The federal ESA requires that the Service and NMFS designate critical habitat for species listed as federally endangered or threatened. "Critical habitat" is defined in ESA as: (1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to a species' conservation, and those features may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation (16 USC 1531 et seq).

Critical habitat has been designated for the following species located within the project area:

- Delta Smelt

**Physical and Biological Features of Critical Habitat**

**Essential Fish Habitat**

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act (Public Law 104 to 297), mandates all federal agencies consult with NMFS on any activities or proposed activities authorized, funded, or conducted by that agency that may adversely impact essential fish

habitat (EFH) of commercially managed marine and anadromous fish species (Section 305(b)(2). These regulations require that federal action agencies provide NMFS with a written assessment of the effects of their action on EFH (50 CFR Section 600.920). EFH includes specifically identified waters and substrate necessary for fish spawning, breeding, feeding, or growing to maturity. Important components of EFH for spawning, rearing, and migration include suitable substrate composition; water quality (e.g., dissolved oxygen, nutrients, temperature); water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity (e.g., large woody debris, pools, channel complexity, aquatic vegetation); space; access and passage; and floodplain and habitat connectivity (Pacific Fishery Management Council 2003). EFH also includes all habitats necessary for the production of commercially valuable aquatic species, to support a long-term sustainable fishery, and contribute to a healthy ecosystem (16 USC 1802[10]).

The SSC is not designated by NMFS to contain EFH for any listed species of fish.

**Fish and Wildlife Coordination Act**

The Fish and Wildlife Coordination Act, as amended in 1964, was enacted to protect fish and wildlife when Federal actions result in the control or modification of a natural stream or body of water. The statute requires Federal agencies to take into consideration the effect that water-related projects would have on fish and wildlife resources. Consultation and coordination with the Service and State fish and game agencies are required to address ways to prevent loss of and damage to fish and wildlife resources and to further develop and improve these resources.

### 3.1.2 Environmental Consequences

***No Action Alternative***

Under the No Action Alternative, Reclamation would not apply nitrogen into the SSC, nor would the broader effort of adaptively managing and exporting plankton to the north Delta occur. Regions of the Bay-Delta ecosystem and habitat for delta smelt would continue to be food-limited.

***Proposed Action***

**Rare and Endangered Plants**

Colusa Grass and Solano Grass generally occurs in vernal pools. Within the Proposed Action area, there is no critical habitat for vernal pool species. The Proposed Action would have no effect on rare and endangered plants.

**California Tiger Salamander (*Ambystoma californiense*)**

California tiger salamanders are typically found in annual grasslands, grass understory of valley foothill woodland, and uncommonly along streams. Adults breed and lay eggs in vernal pools and other temporary ponds. There are no vernal

pools at the project site. The Proposed Action would have no effect on California Tiger Salamander.

**California Red-Legged Frog (*Rana aurora draytonii*)**
Red-legged frogs (CRF) require variety of habitat types including aquatic, riparian and upland areas. Adults often utilize dense, shrubby or emergent vegetation closely associated with deep-water pools with fringes of cattails and dense stands of overhanging vegetation such as willows.

In addition to there being no Critical Habitat in SSC, the Proposed Action would also occur outside of the CRF breeding season. The Proposed Action would have no effect on the California Red-Legged Frog.

**Vernal Pools**
There is no vernal pool habitat within the project area. Vernal pools are generally not present within the active floodplain. The Proposed Action would have no effect on vernal pools.

**Fisheries**

Delta Smelt have Critical Habitat within the project area. Given that a DIN of 0.5 mg/L is the concentration that occurs naturally before nitrogen is drawn down to below detection by phytoplankton uptake, a proposed target level of DIN of 0.5 mg N/L is not expected to have detrimental aquatic ecosystem effects on the SSC, and, therefore, would not have any negative effect on native fish species.

The California Department of Fish and Wildlife has been sampling four stations in the SSC as part of its Summer Townet (STN) and Fall Mid-Water Trawl (FMWT)surveys since 2009 (Figure 11). Although Delta Smelt are frequently observed at STN station #797, which is within the ship channel's turbidity maximum zone, and at station #719, which exchanges water with the Cache Slough Complex, the experiment would occur far upstream near station #796. Since 2011, the STN has captured 8 fish at that location, two in 2011 and 6 in 2012 (Table 1).

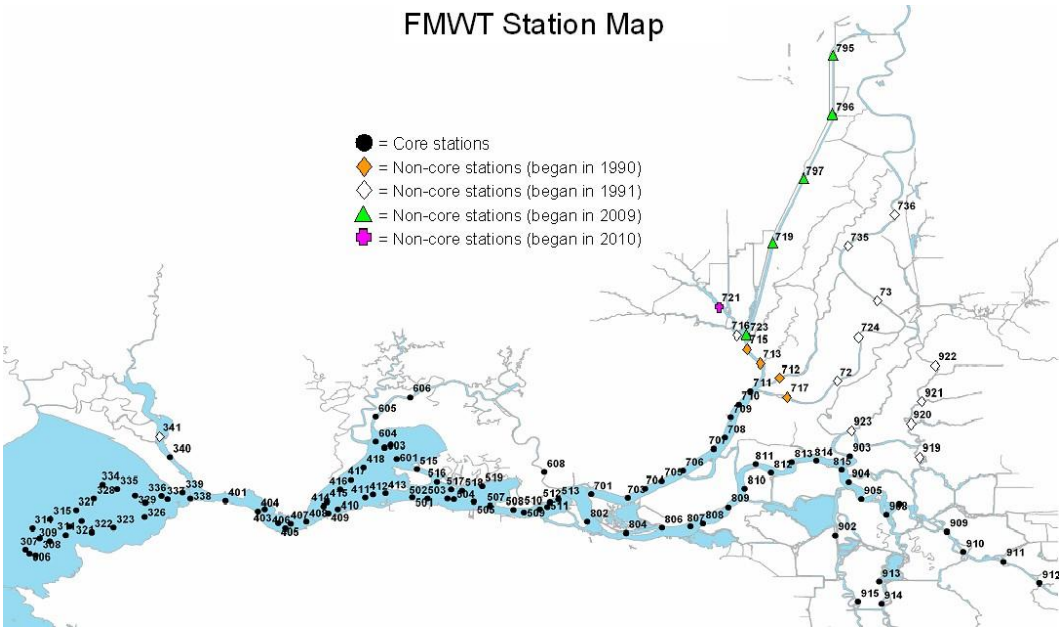

Figure 11. Location of California Department of Fish and Wildlife Fall Mid-Water Trawl stations.

Table 1. Delta smelt catch at California Department of Fish and Wildlife Summer Townet Survey stations located in the Sacramento Deep Water Ship Channel, 2009-2017.

| Year | Survey | Station Code | Sample Date | Secchi | Temperature Top | Conductivity Top | TideCode | Depth Bottom | Delta Smelt |
|---|---|---|---|---|---|---|---|---|---|
| 2011 | 5 | 797 | 8/9/2011 | 31 | 24.6 | 731 | 4 | 34 | 1 |
| 2012 | 5 | 797 | 8/6/2012 | 30 | 23.7 | 767 | 2 | 32 | 5 |
| 2013 | 1 | 797 | 6/11/2013 | 23 | 21.1 | 682 | 2 | 32 | 8 |
| 2013 | 2 | 797 | 6/24/2013 | 33 | 21.0 | 709 | 2 | 35 | 4 |
| 2014 | 1 | 797 | 6/2/2014 | 32 | 21.2 | 773 | 2 | 33 | 12 |
| 2015 | 2 | 797 | 6/18/2015 | 41 | 22.7 | 692 | 2 | 31 | 1 |
| 2017 | 2 | 797 | 6/26/2017 | 27 | 24.1 | 808 | 4 | 34 | 1 |
| 2017 | 3 | 797 | 7/10/2017 | 20 | 25.6 | 786 | 4 | 30 | 1 |
| 2011 | 1 | 796 | 6/14/2011 | 48 | 22.0 | 965 | 3 | 33 | 1 |
| 2011 | 2 | 796 | 6/28/2011 | 46 | 21.6 | 945 | 2 | 34 | 1 |
| 2012 | 1 | 796 | 6/11/2012 | 40 | 22.4 | 1035 | 2 | 32 | 2 |
| 2012 | 2 | 796 | 6/25/2012 | 38 | 22.1 | 1050 | 2 | 35 | 2 |
| 2012 | 4 | 796 | 7/24/2012 | 39 | 22.9 | 948 | 2 | 35 | 2 |
| 2011 | 3 | 795 | 7/12/2011 | 62 | 24.7 | 981 | 3 | 35 | 1 |

During the September-October period, when the experiment is slated to occur, four Delta Smelt have historically been captured at stations 795 and 796, the two closest to where the nutrient addition experiment will be conducted (Table 2). No smelt have been captured by this survey since 2014 and that was at station 719, some 19 km downstream of the experimental reach and well beyond its zone of influence. The experiment is thus not likely to adversely affect Delta Smelt. On

the contrary, by potentially stimulating production of zooplankton, the experiment could in theory benefit any Delta Smelt within the study reach.

Table 2. Delta smelt catch at California Department of Fish and Wildlife Fall Mid-Water Trawl Survey stations located in the Sacramento Deep Water Ship Channel, 2009-2017.

| Year | Date | Survey | Station | Water temperature ($^0$C) | Surface EC (µS/cm) | Turbidity (NTUs) | Depth (ft) | Delta Smelt |
|---|---|---|---|---|---|---|---|---|
| 2009 | 9/30/2009 | 3 | 795 | 21.8 | 876 | 17.8 | 36 | 1 |
| 2009 | 10/28/2009 | 4 | 796 | 16.2 | 784 | 32.5 | 37 | 1 |
| 2010 | 9/29/2010 | 3 | 796 | 22.7 | 816 | 23.6 | 35 | 1 |
| 2010 | 10/19/2010 | 4 | 796 | 19.3 | 833 | 18.9 | 35 | 1 |
| 2009 | 9/30/2009 | 3 | 797 | 20.9 | 690 | 37.1 | 32 | 1 |
| 2012 | 10/18/2012 | 4 | 797 | 19.2 | 592 | 35.4 | 34 | 1 |
| 2015 | 10/19/2015 | 4 | 797 | 20.1 | 502 | 40.5 | 38 | 1 |
| 2009 | 10/28/2009 | 4 | 719 | 15.8 | 453 | 42.1 | 33 | 1 |
| 2012 | 10/18/2012 | 4 | 719 | 18.6 | 327 | 25.9 | 35 | 1 |
| 2014 | 9/17/2014 | 3 | 719 | 22.1 | 400 | 17.2 | 34 | 1 |

The fertilizer to be used for this experiment comes in the form of 1 mm diameter granules that will be deposited by crop duster from an elevation of roughly 10 m. Each granule weighs about 4 mg. In quiescent water, the granules sink at an average speed of roughly 0.1m/s and are expected to be fully dissolved within the top 1 m of the water column. The kinetic energy of a 4 mg granule moving at this velocity is roughly 2 x $10^{-8}$ J, which would be barely perceptible and thus not likely to harm any Delta smelt present near the surface.

## 3.2 Hydrology and Water Quality

### 3.2.1 Affected Environment

**Hydrology**

Under the Propose Action, Reclamation would not be altering the hydrology of flows of SSC or any surrounding bodies of water.

**Water Quality**

The lock area in the uppermost section of the SSC receives a small amount of flow from the Sacramento River as a result of leakage through the sector gates

(which are currently locked in a closed position). The lower SSC exchanges water tidally with Cache Slough and the lower Sacramento River. The main sources of water from the Sacramento River are rain and snowmelt that collect upstream in reservoirs and are released in response to water needs or flood control. The quality of surface water within the downstream portions of Sacramento River is also influenced by other human activities including; historical mining, agricultural, and municipal and industrial (M&I) activities. Water quality issues within the primary project area include the presence of mercury, pesticides, trace metals, turbidity, and toxicity from unknown origin (CALFED 2000a).

### 3.2.2 Environmental Consequences

***No Action Alternative***

Under the No Action Alternative, Reclamation would not apply nitrogen into the SSC, nor would the broader effort of adaptively managing and exporting plankton to the north Delta occur. Therefore, no impacts on hydrology or water quality would occur.

***Proposed Action***

**Water Quality**

The Proposed Action would be completed in accordance with permit conditions and Best Management Practices (BMP) to protect water quality. These practices would prevent fuels, hazardous materials, and other pollutants from entering the ship channel.

Excessive concentrations of nitrate can cause excessive growth of algae and other plants, leading to accelerated eutrophication, and occasional loss of dissolved oxygen. In order to mitigate these detrimental effects, a proposed target level of DIN of 0.5 mg N/L will be conducted for this nitrogen enrichment study. Previous studies of nutrient:chlorophyll stoichiometry in the north Delta indicate that 0.5 mg N/L should produce a maximum of 50 µg/L of chlorophyll. Thus, if all the nitrogen were immediately incorporated into algal biomass (assuming no grazing, no denitrification, no algal sedimentation), the maximum 50 µg/L chlorophyll level would not be expected to have any detrimental aquatic ecosystem effects, such as eutrophication and hypoxia. The N enrichment target of 0.5 mg/L compares to maximum seasonal DIN levels of roughly 0.4 mg/L experienced naturally at or around NL74 (Fig. 7). The enrichment study will occur in late-September. This will restore nitrogen levels that occur naturally earlier in the season before drawdown by phytoplankton growth.

The fertilizer to be used for this experiment contains 1% ammonium nitrogen ($NH_4$-N). It has been hypothesized that ammonium favors the growth of Microcystis, a potentially harmful cyanobacterium that can release microcystin, a neurotoxin, into the water column. Microcystis is observed in the Delta, but has never been observed in the SSC outside of the tidal exchange zone with Cache Slough. Under natural conditions, $NH_4$-N in the study reach since 2012 has

ranged between below detection to roughly 0.07 µg/L. The addition of the fertilizer would increase $NH_4$-N by 0.004 µg/L, an insignificant change.

The aerial application of nitrogen will be conducted by crop-duster. The crop-duster will provide certification that the equipment used will be pesticide/herbicide-free

**National Pollutant Discharge Elimination System (NPDES)**
Section 402 of the Clean Water Act (CWA) specifically required Environmental Protection Agency (EPA) to develop and implement the NPDES program. In California, EPA authorizes the State Water Resources Control Board (SWRCB) to oversee the NPDES program.

Reclamation is in the process of applying for a NPDES permit as covered under the Limited Threat General Order.

The Limited Threat General Order applies to Reclamation as the proposed action involves:

- Clean or relatively pollutant-free wastewaters that pose little or no threat to water quality
    - Discharge of less than 0.25 million gallons per day (MGD) or less than 4 months in duration or
    - Discharges greater than or equal to 0.25 MGD and greater than or equal to 4 months in duration
- Wastewater that may contain toxic organic constituents, volatile organic compounds (VOC), petroleum fuel pollution constituents, pesticides, inorganic constituents, chlorine, and other chemical constituents for which treatment technologies are well-established to eliminate constituents that pose a threat to water quality and that require treatment prior to discharge (CRWQB).

The following BMPS are included to minimize adverse impacts to water quality:

- All equipment working within the ship channel would be inspected daily for fuel, lubrication, and coolant leaks; and for leak potentials (e.g. cracked hoses, loose filling caps, stripped drain plugs); and all equipment must be free of fuel, lubrication, and coolant leaks.
- Vehicles or equipment would be washed/cleaned only at approved off-site areas.

## 3.3 Recreation

### 3.3.1 Affected Environment

Recreational activities occur throughout the SSC, and predominantly include fishing and boating opportunities.

### 3.3.2 Environmental Consequences

***No Action Alternative***

Under the No Action Alternative, Reclamation would not apply nitrogen into the SSC, nor would the broader effort of adaptively managing and exporting plankton to the north Delta occur. Therefore, no impacts to recreation would occur.

***Proposed Action***

Impacts to recreational fishing opportunities on the SSC would not occur. As described previously, the proposed target level of DIN 0.5 mg N/L is not expected to have any detrimental aquatic ecosystem effects and, therefore, would not affect local fish populations or impede fishing opportunities.

Additionally, impacts to boating recreational activities are not expected to occur. Use of a crop duster and the 40ft research vessel are not expected to impact boating traffic in the SSC. Use of the YSI water quality sondes and collection of grab samples are also not expected to have an impact. Therefore, the Proposed Action would not impact recreational activities in the SSC.

## 3.4 Environmental Commitments

Environmental commitments are measures or practices adopted to reduce or avoid adverse effects that could result from project implementation. These are also known as protective measures and are in accordance with relevant permits. The following section describes the best management practices, environmental commitments, and mitigation measures that would be implemented under the Proposed Action:

**Protection Measure #1 – Water Quality**

- The Proposed Action will occur in late-September. This will restore nitrogen to levels that occur naturally earlier in the season before drawdown by phytoplankton growth.
- The form of nitrogen in the fertilizer to be used for this experiment is 99% nitrate and 1% ammonium nitrogen. The addition of this trace amount of $NH_4$-N is not likely to significantly alter the stoichiometry of the water to favor Microcystis or other potentially harmful algae.

**Protective Measure #2 – Cultural Resources**

- In the unlikely event that human remains are uncovered, the project would cease immediately and Reclamation cultural resource staff would provide direction on how to proceed.
- If human remains are discovered on lands under the jurisdiction of Reclamation, they would be treated in accordance to the provisions of the Native American Graves Protection and Repatriation Act of 1990 (25 U. S. C 3001).
- If human remains are discovered on lands owned by any other non-federal entity, they would be treated in accordance to the provisions in the California Health and Safety Code (HSC 7050.5).

## 3.5 Cumulative Effects

The cumulative effects of implementation of reasonably foreseeable projects and the alternatives as compared to conditions under the No Action Alternative and the Proposed Action are discussed below. Cumulative effects are impacts on the environment that result from the incremental impacts of an alternative when added to other past, present, and reasonably foreseeable future actions of Federal, state, or local agencies or individual entities or persons (40 CFR 1508.7). Such impacts can result from individually minor, but collectively significant, actions taking place over time (40 CFR 1508.8). Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the project area.

Due to the relatively short timeframe and low impact of the Proposed Action, there would not be any significant cumulative effects.

# Section 4 Consultation and Coordination

Several Federal laws, permits, licenses and policy requirements have directed or guided the NEPA analysis and decision making process included in this EA.

## 4.0 Public Review Period

This EA will be available for public comment for five days and additional analysis will be prepared if substantive comments identify impacts that were not previously analyzed or considered.

## 4.1 Federal Laws, Regulations, and Policies

### National Historic Preservation Act (54 USC § 300101 et seq.)

54 U.S.C. § 304108, commonly known as Section 106 of the NHPA, requires that Federal agencies take into consideration the effects of their undertakings on historic properties. Historic properties are cultural resources that are included in,

or eligible for inclusion in, the National Register. The 36 CFR Part 800 regulations implement Section 106 of the NHPA and outline the procedures necessary for compliance with the NHPA. Compliance with the Section 106 process follows a series of steps that are designed to identify if significant cultural resources are present in the proposed action project area and to what level they would be affected by the proposed Federal undertaking.

The proposed project action would have no impact on historical or cultural resources, therefore Reclamation will not consult with the State Historic Preservation Officer (SHPO).

### Section 7 of the Endangered Species Act (16 USC § 1531 et seq.)

Section 7 of the Endangered Species Act requires Federal agencies to ensure that discretionary federal actions do not jeopardize the continued existence of threatened or endangered species or result in the destruction or adverse modification of the critical habitat of these species. Reclamation sent letters to the Service and NMFS in June 2018 seeking concurrence that the proposed action was not likely to adversely affect Delta Smelt, salmonids, or green sturgeon.

### National Pollutant Discharge Elimination System

Reclamation must obtain a NPDES permit from the SWRCB. The NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Reclamation has submitted appropriate NPDES applications to the SWRCB.

# Section 5 References


Baxter, R. L, et al. 2015. An Updated Conceptual Model of Delta Smelt Biology; Our Evolving Understanding of Estuarine Fish. Interagency Ecological Program, Management, Analysis, and Synthesis Team.

CNPS, Rare Plant Program. 2015. Inventory of Rare and Endangered Plants v8-02. California Native Plant Society, Sacramento, California. Website http://www.rareplants.cnps.org Accessed 04 February 2015.

CNDDB [California Natural Diversity Database]. 2018. California Department of Fish and Wildlife's Natural Diversity Database, RareFind Version 5. Accessed April, 2018

CRWQB [California Regional Water Quality Control Board, Central Valley Region] 2016. Order R5-2016-0076-01/NPDES Permit No. CAG995002.

DTSC [Department of Toxic Substances Control], EnviroStor. 2015. Hazardous Waste and Substances List. Website http://www.envirostor.dtsc.ca.gov. [accessed March 3, 2015]

Feyrer, F., et al. 2004. Fish Assemblages of Perennial Floodplain Ponds of the Sacramento River, California (USA), With Implications for the Conservation of Native Fishes. Fisheries Management and Ecology 11:335-344.

Frantzich, J and T. Sommer. 2015 Yolo Bypass as a Fall Web Subsidy for the Lower Estuary. Interagency Ecological Program Newsletter 28(1): 3-13

Jassby A. 2008. Phytoplankton in the Upper San Francisco Estuary: Recent Biomass Trends, Their Causes and Their Trophic Significance. San Francisco Estuary and Watershed Science 6.

Kimmerer, W. J. 2002. Effects of Freshwater Flow on Abundance of Estuarine Organisms: Physical Effects on Trophic Linkages? Marine Ecology Progress Series 243: 39-55.

Lehman, P.W., et al. 2013. Long-Term Trends and Casual Factors Associated with Microcystis Abundance and Toxicity in San Francisco Estuary and Implications for Climate Change Impacts. Hydrobiologia 718(1): 141-158.

Mueller-Solger, A.B., et al. 2002. Nutritional Quality of Food Resources for Zooplankton (*Daphina*) in a Tidal Freshwater System (Sacramento-San Joaquin Delta). Limnology and Oceanography 47:1468-1476.

NMFS, 2006. Sacramento Deep Water Ship Channel Maintenance Dredging and Bank Protection Project Biological Opinion 3006/00041. August 29, 2006

Bureau of Reclamation [Reclamation]. 2016. Upper Sacramento River Anadromous Fish Habitat Restoration Program

Sommer, T. and F. Mejia. 2013. A Place to Call Home: A Synthesis of Delta Smelt Habitat in the Upper Sand Francisco Estuary. San Francisco Estuary and Watershed Science. [online serial] 11(2).

Sommer, T. R., et al. Floodplain Rearing of Juvenile Chinook Salmon: Evidence of Enhanced Growth and Survival. Canadian Journal of Fisheries and Aquatic Sciences 58:325-333.

SWCA, 2009. Stockton and Sacramento Deepwater Ship Channel Maintenance Dredging Project 2008 Fish Community and Entrainment Monitoring Report. Prepared for US Army Corps of Engineers Sacramento District. Prepared by SWCA Environmental Consultants, Portland, Oregon. April 2009.

USACE [U.S. Army Corps of Engineers]. 2011. Draft SEIS/SEIR Sacramento River Deep Water Shipping Channel.

USFWS. 1994a. Endangered and Threatened Wildlife and Plants; Critical Habitat Determination for the Delta Smelt. Federal Register 59: 65256-65278

USFWS [U.S. Fish and Wildlife Service]. 1998. Draft Recovery Plan for the Least Bell's Vireo (*Vireo bellii pusillus*). Portland, Oregon. May 1998.

USFWS. 1999. Conservation Guidelines for the Valley Elderberry Longhorn Beetle. Sacramento, California. July 1999.

USFWS. 2002. Recovery Plan for the California Red-legged Frog (*Rana aurora draytonii*). September 12, 2002.

USFWS. 2005a. Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon. Portland, Oregon. 606 pages.

USFWS. 2005b. Revised Guidance on Site Assessments and Field Surveys for the California Red-legged Frog. August 2005

USFWS. 2006. Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*) 5-Year Review: Summary and Evaluation. September 2006.

USFWS. 2007. National Bald Eagle Management Guidelines. May 2007.

USFWS. 2015a. Fish and Wildlife Service. Birds Protected by the Migratory Bird Treaty Act. http://www.fws.gov/migratorybirds/. Accessed: 2018

USFWS. 2015b. Sacramento Fish and Wildlife Office. Endangered Species List. http://www.fws.gov/sacramento Accessed: 2018

Van Nieuwenhuyse, E. E. 2007. Response of Summer Chlorophyll Concentration to Reduced Total Phosphorus Concentration in the Rhine River (Netherlands) and the Sacramento-San Joaquin Delta (California, USA). Canadian Journal of Fisheries and Aquatic Sciences 64: 1529-1542.

Van Nieuwenhuyse, E.E. et al. 2011. Nutrient Enrichment Experiments in the Delta-Mendota Canal, Central Valley Project, California. Bureau of Reclamation, Mid-Pacific Region, Sacramento, California. 54 p.